

## AMENDMENT

## MARKED-UP VERSION OF THE CLAIMS

Kindly amend Claims 3 - 8, 10, and add claims 21 - 30. A complete set of marked-up claims is as follows.

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AI 1. A method of fabricating a semiconductor device, having a copper-zinc alloy (Cu-Zn) thin film formed on a copper (Cu) surface by electroplating the Cu surface in a chemical solution, comprising the steps of:

5 providing a semiconductor substrate having a Cu surface;

providing a chemical solution;

electroplating the Cu surface in the chemical solution, thereby forming a Cu-Zn alloy thin film on the Cu surface;

rinsing the Cu-Zn alloy thin film in a solvent;

drying the Cu-Zn alloy thin film under a gaseous flow; and

10 completing formation of the semiconductor device.

2. A method, as recited in Claim 1, wherein the chemical solution is nontoxic and aqueous, and wherein the chemical solution comprises:

at least one zinc (Zn) ion source for providing a plurality of Zn ions;

at least one copper (Cu) ion source for providing a plurality of Cu ions;

5 at least one complexing agent for complexing the plurality of Cu ions;

at least one pH adjuster; and

at least one wetting agent for stabilizing the chemical solution, all being dissolved in a volume of deionized (DI) water.

3. (**currently amended**) A method, as recited in Claim 2 ~~+~~, wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected from a group consisting essentially of zinc acetate ((CH<sub>3</sub>CO<sub>2</sub>)<sub>2</sub>Zn), zinc bromide (ZnBr<sub>2</sub>), zinc carbonate hydroxide (ZnCO<sub>3</sub>·2Zn(OH)<sub>2</sub>), zinc dichloride (ZnCl<sub>2</sub>), zinc citrate ((O<sub>2</sub>CCH<sub>2</sub>C(OH)(CO<sub>2</sub>)CH<sub>2</sub>CO<sub>2</sub>)<sub>2</sub>Zn<sub>3</sub>), zinc iodide (ZnI<sub>2</sub>), zinc L-

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- 5 lactate  $((\text{CH}_3\text{CH}(\text{OH})\text{CO}_2)_2\text{Zn})$ , zinc nitrate  $(\text{Zn}(\text{NO}_3)_2)$ , zinc stearate  $((\text{CH}_3(\text{CH}_2)_{16}\text{CO}_2)_2\text{Zn})$ , zinc sulfate  $(\text{ZnSO}_4)$ , zinc sulfide  $(\text{ZnS})$ , zinc sulfite  $(\text{ZnSO}_3)$ , and their hydrates.

4. **(currently amended)** A method, as recited in Claim 2  $\pm$ ,

wherein the chemical solution further comprises at least one complexing agent for complexing the plurality of Zn ions being dissolved in the volume of DI water,

- 5 wherein the at least one complexing agent for complexing the plurality of Zn ions comprises tartaric acid  $(\text{HO}_2\text{CCH}(\text{OH})\text{CH}(\text{OH})\text{CO}_2\text{H})$ , and

wherein the tartaric acid prevents precipitation of the plurality of Zn ions from the chemical solution.

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cont.

- 5 5. **(currently amended)** A method, as recited in Claim 2  $\pm$ , wherein the at least one copper (Cu) ion source comprises at least one copper salt selected from a group consisting essentially of copper(I) acetate  $(\text{CH}_3\text{CO}_2\text{Cu})$ , copper(II) acetate  $((\text{CH}_3\text{CO}_2)_2\text{Cu})$ , copper(I) bromide  $(\text{CuBr})$ , copper(II) bromide  $(\text{CuBr}_2)$ , copper(II) hydroxide  $(\text{Cu}(\text{OH})_2)$ , copper(II) hydroxide phosphate  $(\text{Cu}_2(\text{OH})\text{PO}_4)$ , copper(I) iodide  $(\text{CuI})$ , copper(II) nitrate hydrate  $((\text{CuNO}_3)_2)$ , copper(II) sulfate  $(\text{CuSO}_4)$ , copper(I) sulfide  $(\text{Cu}_2\text{S})$ , copper(II) sulfide  $(\text{CuS})$ , copper(II) tartrate  $((\text{CH}(\text{OH})\text{CO}_2)_2\text{Cu})$ , and their hydrates.

6. **(currently amended)** A method, as recited in Claim 2  $\pm$ ,

5 wherein the at least one complexing agent for the plurality of Cu ions comprises at least one species selected from a group consisting essentially of ethylene diamine "EDA"  $(\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2)$  and ethylenediaminetetraacetic acid "EDTA"  $((\text{HO}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2)$ , and

wherein the at least one complexing agent for the plurality of Cu ions prevents precipitation of the plurality of Cu ions from the chemical solution.

7. **(currently amended)** A method, as recited in Claim 2  $\pm$ , wherein the at least one pH adjuster comprises at least one pH-adjusting compound selected from a group consisting essentially of ammonium hydroxide  $(\text{NH}_4\text{OH})$  and tetramethylammonium hydroxide "TMAH"  $((\text{CH}_3)_4\text{NOH})$ .

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8. (**currently amended**) A method, as recited in Claim 2  $\pm$ , wherein the at least one wetting agent comprises a surfactant, and wherein the surfactant comprises at least one material selected from a group consisting essentially of RE-610<sup>TM</sup> and polyethylene glycol (PEG).

9. A method, as recited in Claim 1,

wherein the Cu surface is formed by a process selected from a group consisting essentially of chemical vapor deposition (CVD), plasma vapor deposition (PVD), plasma enhanced chemical vapor deposition (PECVD), electroplating, and electroless plating,

wherein said solvent comprises water, and

wherein said gaseous flow comprises gaseous nitrogen (GN<sub>2</sub>).

10. (**currently amended**) A method, as recited in Claim 2  $\pm$ ,

wherein the at least one zinc (Zn) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L,

wherein the at least one complexing agent for complexing the plurality of Zn ions is provided in a concentration range of approximately 10 g/L to approximately 30 g/L,

wherein the at least one copper (Cu) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L,

wherein the at least one complexing agent for complexing the plurality of Cu ions is provided in a concentration range of approximately 40 g/L to approximately 100 g/L,

wherein the at least one pH adjuster is provided in a concentration range of approximately 10 g/L to approximately 20 g/L,

wherein the at least one wetting agent is provided in a concentration range of approximately 0.01 g/L to approximately 0.1 g/L, and

wherein the volume of DI water is provided in a volume range of up to and including 1 L,

wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 7.5 to approximately 14,

wherein the chemical solution is maintained at a temperature in a range of approximately 16°C to approximately 35°C,

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20 wherein the Cu surface is immersed for a time duration in a range of approximately 15 seconds to approximately 120 seconds,

wherein the Cu-Zn alloy thin film is formed having a thickness in a range of approximately 10 nm to approximately 200 nm, and

25 wherein the formed Cu-Zn alloy thin film is Zn content in a concentration range of approximately 0.10 atomic % to 1 atomic %.

11. (Cancelled)

12. (Cancelled)

13. (Cancelled)

14. (Cancelled)

15. (Cancelled)

16. (Cancelled)

17. (Cancelled)

18. (Cancelled)

19. (Cancelled).

20. (Cancelled)

21. (new) The method of Claim 2 wherein the at least one complexing agent comprises ethylenediaminetetraacetic acid "EDTA"  $((\text{HO}_2\text{CCH}_2)_2\text{NCH}_2\text{CH}_2\text{N}(\text{CH}_2\text{CO}_2\text{H})_2)$ .

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22. (new) The method of Claim 2 wherein the at least one pH adjuster comprises tetramethylammonium hydroxide "TMAH"  $((\text{CH}_3)_4\text{NOH})$ .

23. (new) The method of Claim 2 wherein the at least one wetting agent comprises RE-610™ wetting agent.

24. (new) The method of Claim 2 wherein electroplating the Cu surface in the chemical solution comprises electroplating the Cu surface in the chemical solution thereby forming the Cu-Zn alloy thin film, wherein the Cu-Zn alloy thin film has a Zn content in a concentration range of approximately 0.10 atomic % to approximately 1 atomic %.

25. (new) The method of Claim 2 wherein:

the at least one zinc (Zn) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L; and

the at least one copper (Cu) ion source is provided in a concentration range of approximately 5 g/L to approximately 25 g/L.

26. (new) The method of Claim 2 wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 7.5 to approximately 14.

27. (new) The method of Claim 2 wherein the at least one pH adjuster adjusts the chemical solution to a pH in a range of approximately 10 to approximately 12.

28. (new) The method of Claim 2 wherein the at least one copper (Cu) ion source comprises copper(II) sulfate ( $\text{CuSO}_4$ ).

29. (new) The method of Claim 2 wherein the at least one zinc (Zn) ion source comprises zinc dichloride ( $\text{ZnCl}_2$ ).

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30. (new) The method of Claim 2 the at least one complexing agent comprises ethylene diamine "EDA" ( $\text{H}_2\text{NCH}_2\text{CH}_2\text{NH}_2$ ).

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